RECD 29 APR 2004
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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P044473PCT KET/jdo	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/NL 03/00048	International filing date *(day/month/year)* 23.01.2003	Priority date *(day/month/year)* 24.01.2002
International Patent Classification (IPC) or both national classification and IPC G01P3/487		
Applicant AB SKF et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
22.08.2003	28.04.2004
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Pflugfelder, G Telephone No. +31 70 340-2890

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL 03/00048

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

3-6	as originally filed
1, 2	received on 26.03.2004 with letter of 26.03.2004

Claims, Numbers

1-8	received on 26.03.2004 with letter of 26.03.2004

Drawings, Sheets

1/1	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-8
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-8
Industrial applicability (IA)	Yes:	Claims	1-8
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

D1: DE 198 10 218 A (GINTNER KLEMENS) 15 October 1998 (1998-10-15)
D2: EP-A-0 952 429 (HENGSTLER GMBH) 27 October 1999 (1999-10-27)
D3: DE 197 17 364 C (SIEMENS AG) 27 August 1998 (1998-08-27)

1. NOVELTY

Document D1 (see column 9, lines 29-41; claim 10, figure 17) discloses:
-a rotational speed sensor comprising a rotatable ring (18) having K magnetic pole pairs distributed angularly over the rotatable ring (18), K being an integer greater than one;
- a pair of magnetic field sensor means (SE1,SE2) being positioned relative to the rotatable ring 2 x pi x (L/K) radians apart from each other (= lambda/R (with lambda := 2 x pi x R/K; L=1)).

Document D1 does not show the feature that:
-the sensor means comprise at least one second pair of magnetic sensors, the second pair of sensors being positioned 2 x pi x M/K radians apart from each other, M being an integer between 1 and K-1, the first pair of sensors and second pair of sensors being positioned at a relative position of (2 x pi/K) x ((2n-1)/2) radians, n being an integer greater than one.

Claim 1 thus meets the requirement of novelty of Article 33 (1),(2) PCT.

2. INVENTIVE STEP

The above mentioned feature being novel over D1 has the technical effect that the sensor *provides an even better jitter resistant signal, ... the resulting sine wave* being *of a better quality* (see e.g. description of the application: page 4, line 29 - page 5, line 6).

The problem to be solved by this differing feature can therefore be seen as to further improve the performance with respect to jitter.

The skilled person, seeking for a solution to this problem is aware of the general nature of the output signal jitter of rotational speed sensors having incremental encoders as lying in the imperfection (*manufacture tolerances*) of the encoder. He is aware, that this is true for many kinds of sensors and encoders and not only for magnetic ones. He would therefore consider technical solutions, which deal with the general problem of jitter reduction of output signals of rotational speed sensors caused by imperfect encoders, and he would consult the general field of incremental encoder based rotational speed sensing and the related output signal processing.

The skilled person would then realize that in the document D2 (see paragraphs [0017] - [0022], [0031]; figures 1-3), the same solution as in the characterizing part of claim 1 (sensor arrangement using a further pair of sensors in anti-phase to the first pair) is used for the same purpose ("den Anteil von Rausch- und Störsignalen eliminieren") as in the present application.
It is therefore obvious for the skilled person to use the sensor arrangement and the signal processing means employed with the sensor of D2 (having an imperfect optical incremental encoder) and to employ it for a sensor as the one of D1 (having an imperfect magnetic incremental encoder).

Claim 1 is therefore not considered to involve an inventive step in the sense of Article 33 (3) PCT.

3. DEPENDENT CLAIMS

Dependent claims 2-8 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step, the reasons being as follows:

-claim 2: D1 (see column 9, line 37) discloses the case K=1/2 ("Abstand entspricht ungeradzahligem Vielfachen von lambda/2"); the claim is thus not inventive;
-claim 3: the use of an additional quadrature sensor is e.g. disclosed in D3 (see figures 1,2) and not inventive;

-claim 4: the use of Hall sensors instead of magnetoresistive sensors is well known and not inventive;
-claims 5,6,7: document D2 (see paragraphs [0017] - [0022], [0031]; figures 1-3) discloses the use of a further sensor pair and the corresponding summation and substraction of output signals; the claims are thus not inventive.
--claim 8: the use of rotational speed sensors having integrated signal processing means is well known and not inventive.

4. INDUSTRIAL APPLICABILITY

The claimed invention meets the requirement of Article 33 (4) PCT of industrial applicability.

PCT/NL03/00048 amended page 1

Rotational speed sensor

The present invention relates to a rotational speed sensor comprising a rotatable ring, e.g. connectable to a bearing, having K magnetic pole pairs distributed angularly over the rotatable ring, K being an integer greater than one, and sensor means positioned relative to the rotatable ring such that a varying magnetic field is detected by the sensor means. More particularly, the present invention relates to a rotational speed sensor as defined in the preamble of claim 1.

Such a rotational speed sensor is known from German patent application DE-A-198 10 218.

A further rotation sensor is known from American patent US-A-5,184,069, which describes a rotation sensor for detecting relative rotation between two components which are coupled by an anti-friction bearing. The rotation sensor comprises a tone ring with a layer of magnetic ink, the layer defining multiple magnetic poles, with the north and south poles being alternatively positioned at the circumference of the ring. The rotation sensor further comprises a transducer for detecting a varying magnetic field when the two components rotate with respect to each other.

However, the arrangement according to the prior art is susceptible to a number of error mechanisms. The layer having multiple magnetic poles is difficult to manufacture within very strict tolerances. The distance between north and south oriented magnetic poles on the layer is not always constant over the entire layer circumference. This causes the detected magnetic field to have anomalies when the disc rotates, caused by the phase errors, also indicated by the term jitter.

Further problems occur when the layer on which the magnetic poles are arranged is not making a perfect circular motion. This may be caused by radial movement of the layer with respect to the magnetic sensor, and causes further errors in the sensor output signal.

Also, external magnetic fields may influence the signal generated by the magnetic sensor.

The present invention seeks to provide a rotational speed sensor having an improved performance, especially with respect to jitter.

This is accomplished according to the invention by a rotational speed sensor according to the preamble defined above, having the characterizing features as defined in claim 1.

In such a configuration, the two magnetic sensors of the first pair look at the same pole of different magnetic dipoles. This allows to obtain a signal with a higher signal strength, reducing the effect of jitter. Also, the second pair of sensors looks at the opposing pole of the magnetic dipoles, i.e. in anti-phase with the first pair of magnetic sensors. This allows to cancel out external influences, such as external magnetic fields and temperature effects.

In a further embodiment, L is equal to K/2 (K being an even valued integer), i.e. the magnetic sensors of the first pair are positioned diametrically opposite to each other. This embodiment allows for a reduced sensitivity to jitter, but also a reduced sensitivity to movement of the disc in a direction along the line connecting the two magnetic sensors, i.e. radial movement of the disc.

To allow detection of the direction of rotation, the sensor means may further comprise an additional magnetic sensor, positioned at $(2\pi/K)*((2m-1)/4)$ radians from the first or second pair of magnetic sensors, m being an integer greater than one. From the phase of the additional magnetic sensor signal, compared with the phase of the other magnetic sensors, the direction of rotation may be determined. Depending on the configuration, a phase advance may indicate a clockwise or counter clockwise rotation.

One further embodiment comprises magnetic sensors of the Hall effect type. These kind of sensors allow to operate in a high temperature environment.

In further embodiments, the rotational speed sensor is connectable to signal processing means. The signal processing means may be arranged to add the signals from the magnetic sensors of the first pair to obtain a first sensor pair signal. Also, the signal processing means may be arranged to add the signals from the magnetic sensors of the first pair to obtain a first sensor pair signal and to add the signals from the magnetic sensors of the second pair to obtain a second sensor pair signal and to subsequently subtract the second pair signal from the first pair signal. Furthermore, the signal processing means may be arranged to add the signals from the magnetic sensors of the first pair and/or the second pair to obtain a first sensor pair signal and/or a second sensor pair signal, respectively, and the signal processing means may be further

CLAIMS

1. Rotational speed sensor (10) comprising a rotatable ring (11), e.g. connectable to a bearing, having K magnetic pole pairs (12) distributed angularly over the rotatable ring (11), K being an integer greater than one, and sensor means positioned relative to the rotatable ring such that a varying magnetic field is detected by the sensor means, the sensor means comprising at least a first pair of magnetic sensors (15, 16), the first pair of magnetic sensors (15, 16) being positioned $2\pi L/K$ radians apart from each other, L being an integer between 1 and K-1, characterized in that the sensor means comprise at least one second pair of magnetic sensors (17, 18), the second pair of sensors (17, 18) being positioned $2\pi M/K$ radians apart from each other, M being an integer between 1 and K-1, the first pair of sensors (15, 16) and second pair of sensors (17, 18) being positioned at a relative position of $(2\pi/K)*((2n-1)/2)$ radians, n being an integer greater than one.

2. Rotational speed sensor according to claim 1, in which K is an even integer value and L is equal to K/2.

3. Rotational speed sensor according to claim 1 or 2, in which the sensor means further comprise an additional magnetic sensor (19), positioned at $(2\pi/K)*((2m-1)/4)$ radians from the first or second pair of magnetic sensors (15-18), m being an integer greater than one.

4. Rotational speed sensor according to one of the claims 1 through 3, in which each of the magnetic sensors (15-19) is a Hall type sensor.

5. Rotational speed sensor according to one of the claims 1 through 4, in which the rotational speed sensor (10) is connectable to signal processing means (20), the signal processing means (20) being arranged to add the signals from the magnetic sensors of the first pair (15, 16) to obtain a first sensor pair signal.

6. Rotational speed sensor according to one of the claims 1 through 5, in which the rotational speed sensor (10) is connectable to signal processing means (20-22), the

signal processing means (20-22) being arranged to add the signals from the magnetic sensors of the first pair (15, 16) to obtain a first sensor pair signal and to add the signals from the magnetic sensors of the second pair (17, 18) to obtain a second sensor pair signal and to subsequently subtract the second pair signal from the first pair signal.

7. Rotational speed sensor according to claim 3 or 4, in which the rotational speed sensor (10) is connectable to signal processing means (20-23), the signal processing means (20-23) being arranged to add the signals from the magnetic sensors of the first pair (15, 16) and/or the second pair (17, 18) to obtain a first sensor pair signal and/or a second sensor pair signal, respectively, and in which the signal processing means (20-23) are arranged for determining a speed direction from the first sensor pair signal and/or the second pair signal and the signal from the additional magnetic sensor (19).

8. Rotational speed sensor according to one of the claims 5, 6, or 7, in which the sensor means (15-19) and signal processing means (20-23) are integrated.

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